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ABSTRACT

Nine lessons which involve the use of marine organisms in the classroom are presented in this seventh-grade biology unit. The unit offers instructors alternative ways of meeting common life science goals. It is not meant to be an extra curriculum added to the normal course load, but was developed to consolidate a group of activities designed for the study of marine organisms in a classroom situation. Each lesson includes lesson concept, competency goals, objectives, list of vocabulary words, materials needed, background information, student and teacher preparation, and a set of humane activities to help reach the desired goals. These activities examine such areas as dependence of organisms on non-living environmental factors, characteristics of brine shrimp, behavior of fiddler crabs, and the identification of the incurrent and excurrent siphons of a coquina clam. Introductory material includes: (1) information on setting up salt water aquaria; (2) feeding schedule for marine animals; (3) information on holding tanks; (4) list of supply houses for aquaria apparatus and marine organisms; (5) code of practice on animals in schools; and (5) methods for collecting marine organisms. Materials to be duplicated for student use are included. (JN)

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A PROJECT CAPE RESOURCE

Developed under an ESEA Title IV-C Grant

Dare County Board of Education
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SC-1

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UNIT CONCEPTS

WATER AND NATURE

Water affects living organisms.

1. Water sustains all living organisms.
2. Water provides habitats and protection for living organisms.
3. Water provides transportation for living organisms.
4. Water affects the population distribution of living organisms.
5. Organisms and aquatic environments are in constant change.
6. Aquatic organisms are adapted to their environment in different ways.
7. Aquatic organisms interact in balance with their environment and with other organisms.

INTRODUCTION

Many of today's educational materials are based upon land resources, with little emphasis placed on one of our most valuable resources, the sea. The importance of the proper management of marine resources has not been stressed. As a result, our fragile coastal habitats have been abused through inappropriate management and misuse. A new awareness of our coastal resources is growing with the increase in pollution, population and food demand. It is the task of marine education to give the public accurate information that may help in dealing with these problems.

The future of our coastal resources depends not only on adult education but also the education of our youth. Few materials exist for leading youth in humane live animal investigations, particularly materials dealing specifically with marine organisms.

Each lesson in this module is designed to meet specific competency goals and contains a set of humane activities to help reach these goals. The module offers the instructor alternative ways of meeting common life science educational goals and is not meant to be an extra curriculum added to the normal course load. This module was developed to consolidate a group of activities designed for the study of marine organisms in a classroom situation. Each lesson can be used separately to teach specific concepts or as a complete unit to lead students in investigations of marine organisms.

--Carolyn H. Hampton

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SALT WATER AQUARIUMS

Salt water aquariums serve as useful teaching aids in the classroom. Following a few simple rules and guidelines, aquariums can be easily established and maintained. The key to a successful aquarium is proper maintenance.

Equipment

Aquarium

When selecting a tank, care should be taken to avoid tanks whose seams are metal. Salt water corrodes metal which can contaminate the tank. Choose a tank constructed of glass or of plexiglass. Tanks having a 75 to 110 liter (20 to 30 gallon) capacity are recommended because they will house a greater variety of organisms.

Filter

An effective filtration system is needed to reduce toxicity of ammonia, a waste product of fish and invertebrates. Two types of filtration are available: biological and mechanical. Of the two, a biological or undergravel filter is preferred. Instructions are included with each type of filter and should be followed carefully. Both types require an air pump for operation.

In biological filtration the water filters down through the gravel and substrate. Nitrifying bacteria and other microorganisms act on waste products and decaying matter to convert ammonia to a less toxic compound called nitrite. Other microorganisms convert nitrites to nitrates. The nitrates are used by green algae as nutrients.

Mechanical filters may be used in conjunction with biological filters to improve water quality. Mechanical filters attach to the outside of

the tank and improve the general quality of the water and increase the dissolved oxygen content. In a mechanical filter, water moves down through polyester fibers where large particles are removed and then into a layer of activated charcoal where organic molecules are removed.

Water

Natural sea water or commercial sea salts may be used. Whenever possible, water from the organisms' natural habitat should be used. Do not collect the water near shore as it has a greater chance of being contaminated. Move into deeper water to collect the water. Use plastic buckets for storing the water and collect enough for water changes and maintenance. The extra water should be stored in a dark place with lids secured to prevent algae growth. Before using natural sea water in the aquarium, always filter it through polyester fibers to remove suspended particles.

Commercial sea salts are packaged as a dry mixture and should be mixed with aged tap water (water which has stood uncovered for 72 hours) to produce a sea water solution. Use salts from a reputable distributor and follow the package directions when mixing. If using commercial sea salts it is best to always use the same brand in the aquarium. If chlorinated water is used to mix sea water, a chemical is available at a pet shop or biological supply company to remove the chlorine.

Substrate

Avoid using siliceous gravel, sand or colored pebbles as a substrate. Choose a substrate that contains calcium carbonates or limestone materials. Good substrates are coquina shells, crushed coral, limestone pebbles and crushed oyster shells. The size of the substrate particles must be larger than the holes in the undergravel filter.

To clean the substrate, run fresh water over it in a plastic container,

stir the contents and pour off the floating particles. Follow this procedure until after the gravel or shells sink to the bottom and the water has a clear appearance.

The Set-up

1. Select a place for the aquarium out of direct sunlight and with access to an electrical outlet.
2. Make sure the tank is clean. If the tank needs cleaning, wash it with a mixture of salt and water and rinse the tank with tap water. Never use soaps or detergents to clean an aquarium or any of its components. Never move the tank containing water or substrate. Moving may weaken the seams and cause leaks.
3. Install the filter(s) to connect the air hoses and air pump according to the filter instructions. The air pump should be placed above the water level to prevent a back flow in case of power failure.
4. Cover the filter of the aquarium with 5 to 7 centimeters of substrate.
5. Place a saucer on the surface of the substrate and fill the tank to within 2 to 3 centimeters from the rim, pouring the water in the saucer to avoid disturbing the substrate.
6. Turn on the air pump and adjust the valves so that the bubbles rise rapidly but separately through the tubes of the filter. Using a grease pencil or a piece of tape, mark the water level on the outside of the tank.
7. Place a lid or cover on the aquarium. This will help to reduce the rate of evaporation.
8. Allow 72 hours of aeration to stabilize the system.
9. It is best to condition the tank with a single organism about a week before adding a full population. Add a hardy organism such as

a crab. This helps to build a nitrifying bacteria population.

Acclimatization of Organisms

Float the containers in which the animals were transported in the aquarium. Every 15 minutes, add a small amount of aquarium water to a container. Continue this until the temperature of the container water is the same as the temperature of the aquarium water. Then introduce the animals to the aquarium.

When feeding the organisms it is important to remember the following guidelines: cut off the power, do not feed the organisms more food than can be consumed in 1 or 2 hours and remove uneaten food after 2 hours. It will help to include a few scavengers to clean up after meals. A schedule for feeding animals can be found at the end of this section.

Maintenance

Maintaining the aquarium can be relatively simple when done on a regular basis.

Light and Temperature

The aquarium should always be kept out of direct sunlight. Sunlight encourages the growth of algae and can overheat the aquarium water. The temperature should be kept between 21° C and 24° C. An aquarium heater may be necessary to maintain a constant temperature if the room temperature fluctuates too greatly.

Salinity

The salt content of the aquarium should be constant. Desired salinity is 30 parts per thousand or a reading of 1.025 on a hydrometer. Evaporation will tend to reduce the amount of water in the aquarium. To replenish the water add distilled or aged tap water to the water level mark on the

tank. Never add more salt water to the tank. This increases the salinity level and can be harmful to the organisms. A glass or plexiglass cover on the tank will help slow the rate of evaporation.

pH

To maintain a pH level of 8.0 to 8.3 a simple procedure can be followed. First, check the water using a test kit available through any biological supply house. If the pH factor falls below 8.0 (becomes too acid) remove a cup of aquarium water and add to it 1 teaspoon of bi-carbonate of soda (baking soda), mix well and pour it back into the tank. Do this each day until the pH level is in the correct range.

Water Changes and Cleaning

Once a month one-fourth of the water should be siphoned off and replenished with fresh sea water. The polyester fibers of mechanical filters should be rinsed with fresh aged tap water and the charcoal should be replaced. Once a week, scrape the side of the aquarium to release any algae build-up. (Do not use a metal scraper.)

Organisms do die. It is important that dead organisms be removed immediately to prevent further contamination.

Equipment Check List

_____ 75 to 110 liter tank	_____ Air Hose
_____ Undergravel Filter	_____ Air Pump
_____ Mechanical Filter (optional)	_____ Substrate
_____ Sea Water (natural or commercial)	_____ Hydrometer
_____ pH Test Kit	_____ Aquarium Thermometer
_____ Organisms	_____ Food For Organisms

FEEDING SCHEDULE		
Organisms	**Food**	**Schedule**
Crabs, starfish, moon snails	Feed chopped fish, shrimp, earthworms, lean beef placed near or under the animal.	Once a week
Sea anemones	Crush food with sea water into a watery paste. Pipette over the tentacles and polyps.	Three times a week
Barnacles, scallops, clams, oysters, sponges, sea squirts	Feed finely powdered fish food, Daphnia, freshly hatched brine shrimp.	Three times a week
Sea urchins	Feed natural growth of algae in tank, small pieces of lettuce or spinach.	Once a week
Killifish, pinfish	Feed dry fish food.	Daily
Silversides	Feed living brine shrimp or Daphnia.	Two times a week
Fiddler crabs, hermit crabs, mud snail, sand dollar, pipe fish	These species will aid in cleaning the aquarium of dead and decaying materials.	

Taken from: Hampton, Carolyn H. and Carol D. Hampton. "Care and Maintenance, A Saltwater Aquarium." Science and Children, Vol. 18, No. 2 (October 1980), 30-32.

TEMPORARY HOLDING TANKS

Many times animals are only needed for a few days for observation and experimentation. It is important that these organisms be made as comfortable as possible during their stay in the classroom.

Small Observation Aquariums

Plastic or glass gallon-sized aquariums are designed to hold only one or a few small organisms. They require a small amount of equipment. Gallon glass jars from a restaurant or cafeteria make good substitutes and are usually obtained at little or no cost.

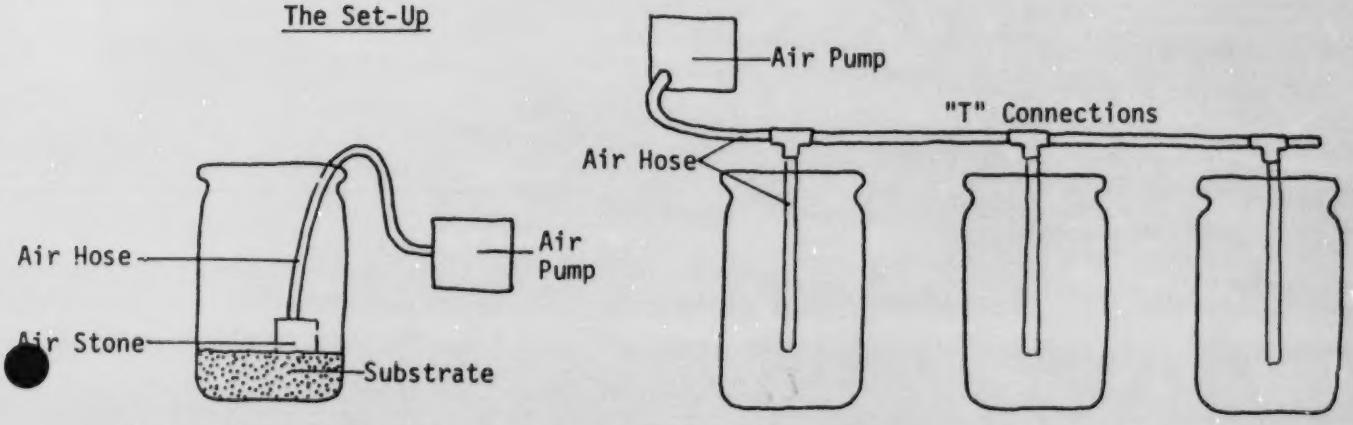
Equipment List

air stone
air pump
substrate
air hose
gallon jar
sea water

Animals

starfish
small fish
sea cucumbers
scallops
small blue crabs

The Set-Up



SINGLE AQUARIUM OR MULTIPLE AQUARIUM

Steps For The Set-Up

1. Select a place for the aquarium, out of direct sunlight and with access to an electrical outlet.
2. Make sure the aquarium is clean. If it needs cleaning, wash it with a mixture of salt and water. Rinse the aquarium with tap water.
3. Cover the aquarium bottom with 3 centimeters of substrate.
4. Add the sea water to within 3 centimeters from the top of the container. This allows for maximum surface area for oxygen exchange.
5. Connect the air stone and air hose to the air pump. The air pump should be placed above the water level to prevent a back flow in case of power failure.

Shallow Water Tanks

Many animals spend part of their life on land and a part of their life in the water. A different type of holding tank is needed for these organisms. Shallow water and plenty of surface area are recommended to give an adequate supply of oxygen.

Equipment List

wooden block
sand or silt
sea water
plastic sweater box or shoe box or glass baking dish

Animals

mud snails
fiddler crab
mole crabs
marsh periwinkle
coquina clams

The Set-Up

Steps For The Set-Up

1. Select a place for the shallow water aquarium out of direct sunlight.
2. Make sure the container is clean. If not, clean it with a mixture of salt and water. Rinse with tap water.
3. Place the edge of the container on a wooden block, or wedge, creating an angle.
4. Place silt or sand in the lower end of the container and add sea water or brackish water.

SUPPLY HOUSES FOR AQUARIA APPARATUS

AND MARINE ORGANISMS

Turtox/Cambosco
MacMIllan Science Co., Inc.
8200 S. Hoyne Avenue
Chicago, IL 60620

Carolina Biological
Burlington, NC 27215

Aquarium Systems, Inc.
1462 E. 289 Street
Wicklittle, OH 44092

Biometal Associates
BioQuip Products
P. O. Box 61
Santa Monica, CA 90406

R. F. Carle Co.
P. O. Box 3155
Chico, CA 95926

Dayno Sales Co.
678 Washington Street
Lynn, MA 01901

Jewel Aquarium Co., Inc.
5005 W. Armitage Avenue
Chicago, IL 60639

NASCO
Fort
Atkinson, WI 53538

Pacific Bio-Marine Supply Co.
P. O. Box 536
Venice, VA 90291

Pets Unlimited
903 Hennepin Avenue
Minneapolis, MN 55403

Southern Biological Supply Co.
McKenzie, TN 38201

CODE OF PRACTICE ON ANIMALS IN SCHOOLS

Position statement of the
National Science Teachers Association
Washington, D.C.

This code of practice is recommended by the National Science Teachers Association for use throughout the United States by elementary, middle/junior high, and secondary-school teachers and students. It applies to educational projects involving live organisms conducted in schools, or in school-related activities, such as science clubs, fairs, competitions, and junior academies.

The purpose of these guildlines is to enrich education by encouraging students to obser living organisms and to learn proper respect for life. Study of living organisms is essential for an understanding of living processes. This study, however, must go hand-in-hand with observation of humane principles of animal care and treatment which are described below. These principles apply to both vertebrates and invertebrates.

A. A teacher must have a sure understanding of and *strong commitment to responsible care of living creatures* before making any dicision to use live organisms for educational purposes. Preparation should include acquisition of knowledge on care appropriate for that species, as well as housing and other equipment needs and food, and planning for care of the living creatures after completion of study.

B. Teachers should try to assure that live organisms entering a classroom are *healthy and free from transmissible diseases* or other problems that may endanger human health. Not all species are suitable. Wild animals, for instance, are frequent carriers of parasites and disease and generally are not appropriate.

C. Of primary importance is *maintenance of good animals health and provision of optimal care* based on an understanding of the life habits of each species. Animal quarters shall be spacious and avoid overcrowding, and be sanitary. Handling shall be gentle. Food shall be palatable to the species and of sufficienty quantity and balance to

maintain a good standard of nutrition at all times. No animals shall be allowed less than the optimum maintenance level of nutrition. Clean drinking water shall always be available. Adequate provision shall be made for the animal's care at all times, including weekends and vacation periods.

D. *Experimental procedures conducted on vertebrate animals shall include only those which do not involve pain* or discomfort to the animal (see details below under "Experimental Studies"),

E. All aspects of animal care and treatment shall be *supervised by a qualified individual* who will ensure that proper standards are maintained.

F. Supervisors and students should be familiar with appropriate *literature on care and handling* of living organisms. Practical training in learning these techniques is encouraged.

G. Adequate plans should be made to *control possible unwanted breeding* of the species during the project period.

H. Appropriate plans should be laid for *what will happen to the living creatures at the conclusion of the study.* Sometimes it may be possible to find a comfortable home for an animal with a responsible person.

I. As a general rule, *laboratory-bred or non-native species should not be released into the wild.* For instance, in some climates, *Xenopus* frogs, or gerbils, if released, can disturb the normal ecosystem or become pests.

J. On rare occasion it may be appropriate to sacrifice an animal for educational purposes. This shall be done in an approved humane (rapid and painless) manner by a person experienced in these techniques and it should *not* be done in the presence of immature or young students who may be upset by witnessing such a procedure. Maximum efforts should be made to study many biological principals and *utilize as many body tissues as possible from a single animal.*

K. The procurement, care and use of animals must comply with existing local, state and federal regulations.

EXPERIMENTAL STUDIES

1. In biological procedures involving living organisms, *species of plants, bacteria, fungi, protozoa, worms, snails, insects and other invertebrate animals should be used whenever possible.* Their wide varieyt, ready availability, and simplicity of maintenance and subsequent disposal make them especially suitable for student work.

2. *Some sample plant, protozoan, and/or invertebrate projects* include field studies and natural history (life cycle, incidence in nature, social structure, etc.); germination; genetics; reproduction; effect of light, temperature, other environemtnal factors, and hormones on growth and development; feeding behavior; nutritional requirements; circulation of nutrients to tissues; metabolism; water balance; excretion; movement; activity cycles and biological clocks; responses to gravity and light; perception to touch, humidity and vibration; learning and maze running; habituation; communication; pheromones; observations of food chains and interdependence of one species on another.

3. *No experimental procedures shall be attempted on mammals, birds, reptiles, amphibians, or fish that cause the animal pain* or discomfort or that interfere with its health. As a rule of thumb, a student shall only undertake those procedures on vertebrate animals that could be done on humans without pain or hazard to health.

4. Students shall *not perform surgery* on vertebrate animals.

5. *Examples of non-painful, non-hazardous projects on some vertebrate species* (including, in some instances, human beings) include some already mentioned under item (2) and also group behavior; normal growth and development; properties of hair; pulse rate and blood pressure; various normal animal behaviors such as grooming, and wall-seeking; reaction to novelty or alarm; nervous reflexes and conditioned responses; special senses (touch, hearing, taste, smell, and proprioceptive responses); and respiration. None of these projects requires infliction of pain or interference with normal health.

6. *Experimental procedures shall not involve* use of micro-organisms which can cause diseases in man or animals, ionizing radiation, cancer-producing agents, or administration of alcohol or other harmful drugs or chemicals known to produce toxic or painful reactions or capable of producing birth defects.

7. *Behavioral studies should use only reward* (such as providing food) and not pumishment (such as electric shock) in training programs. Food, when used as reward, shall not be withdrawn for periods longer than 12 hours.

8. *Diets deficient in essential nutrients are prohibited.*

9. If *bird embryos* are subjected to invasive or potentially damaging experimental manipulations, the embryo must be destroyed humanely two days prior to hatching. If normal embryos are to be hatched, satisfactory humane provisions must be made for the care of the young birds.

10. On rare occasion it may be appropriate to *pith a live frog* for an educational demonstration. Correct procedure is rapid and virtually painless, and the animal should never recover consciousness. However, if done incorrectly, this procedure can cause pain. The technique should be learned initially using dead animals. Pithing live animals should only be undertaken by a person knowledgeable in the technique.

11. *Protocols* of extracurricular projects involving animals *should be reviewed in advance* of the start of work by a qualified adult supervisor. Preferable, extracurricular projects should be conducted in a suitable area in the school.

12. High school students may wish to take assistant positions with professional scientists working in established, USDA-registered research institutions.

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COLLECTION OF MARINE ORGANISMS

Salt marshes, jetties, mud flats and open beaches offer a wealth of hardy organisms which can be kept in salt water aquaria. Careful planning is required to insure that marine organisms get to the classroom alive and healthy. Factors to consider in planning a collection trip are: state laws governing the collection of organisms, selection of collecting sites, collecting equipment, collecting procedures and transportation.

Collecting Permits

Special permits are required by North Carolina and many other states for the collection of marine organisms. These permits are available through the North Carolina Division of Marine Fisheries. Section 3c/.0209 Scientific Collecting Permit states:

> No person shall take any marine or estuarine species which is out of season or otherwise protected for scientific purposes unless he first secures a scientific collecting permit from the secretary. If the secretary determines that the request is for a valid scientific purpose and will not result in a significant adverse effect on fisheries management, the permit will be issued. Such permit will be subject to any restrictions concerning area, times, and sampling methods as the secretary deems appropriate.

A copy of the "Application for Permit to Collect Marine and Estuarine Organisms for Scientific Purposes" is found in the media package. The application should be completed and mailed to: Division of Marine Fisheries, P. O. Box 769, Morehead City, North Carolina, 28557.

Materials for Collection

1. Shovels and trowels - these can be used to dig coquina clams, mole crabs, clams and scallops.
2. Sieves or strainers - used to strain off sand and to make the animals more accessible.
3. Seine nets - used for collecting fish, shrimp and crabs.
4. Dip nets - used to collect small fish.
5. Plastic bags - can be used in the transportation of small fish and marine algae.
6. Buckets and lids - multipurpose use.
7. Wax milk cartons - multipurpose, use as scoops and transportation.
8. Oyster knife - use for prying loose attached organisms.

Collecting and Transporting Plants and Animals

Plants

1. Plants such as Sea Lettuce (Ulva) should be collected attached to rocks and shells. Do not remove the plant from its foundation.
2. Guest Sponge seaweed (Codium) can be collected either attached or unattached to a foundation.

   Hint: For aquarium purposes sea lettuce is the hardier of the two plants.
3. Eel grass (Zostera) should be carefully dug to get the root system.

Organisms	Method
1. Coquina clams Mole crabs	Using a trowel or scoop, dig some wet sand from the surf zone. Empty the trowel or sand into a tea strainer or sieve. Lower the strainer and allow the water to gently flow over it. Drain off the water leaving the organisms in the strainer.

	Organisms	Method
2.	Scallops and clams	Using a trowel or scoop, dig some wet sand from the surf zone. Empty the trowel of sand into a tea strainer or sieve. Lower the strainer and allow the water to gently flow over it. Drain off the water leaving the organisms in the strainer.
3.	Marsh periwinkles	The periwinkles are found on cord grass in salt marshes. They are easily picked off the plants. If periwinkles are to be maintained in the classroom, plots of cord grass should be dug with a shovel, being careful not to damage the roots. Do not shake the soil loose from the plants. Place a plot of cord grass in an aquarium and add enough estuarine water to keep the root system wet.
4.	Starfish and sea urchins	If attached to rocks, jetties, or pilings, starfish should be gently pried off by hand.
5.	Fish, shrimp and blue crabs	These may be collected by using dip nets or by pulling a seine net.
6.	Mud snails	These may be collected in shallow estuarine waters by hand.

Bedding and water levels are important when transporting organisms. Water levels should be shallow. Arrange milk cartons in an ice chest. Place seaweed in the bottom of each carton and put just enough water to cover the seaweed. Place no more than three invertebrate animals on the bed of seaweed. The animals should not be submerged in the water. Fish and shrimp should be transported in buckets containing enough water to cover them.

No matter what is being collected, use good judgement. Never take more than you need and return the animals to their habitats when you are finished.

SOURCE

Hampton, Carolyn H. and Carol D. Hampton. "A Salt Water Aquarium," Science and Children, October 1980.

LESSON NUMBER: 1

A HEALTHY HABITAT

LESSON CONCEPT

Living organisms are dependent upon non-living environmental factors.

COMPETENCY GOALS

1. The learner will understand that communities are affected by limiting factors.

2. The learner will demonstrate skill in the use of instruments.

OBJECTIVES

1. The learner will demonstrate his/her ability to determine the temperature, salinity and pH of an aquarium.

2. The learner will define correctly the terms temperature, salinity and pH.

VOCABULARY

temperature
salinity
pH
density
acid
base

MATERIALS

thermometer
pH color comparator or p-Hydrion paper
copy of supplementary sheets 1.1 - 1.2
hydrometer
graduated cylinder

BACKGROUND INFORMATION

This lesson may be used in conjunction with the establishment of a salt water aquarium. After the students have acquired the skills taught in this lesson, assign individuals to check the aquarium on a regular basis.

Three of the most important environmental factors in maintaining a healthy habitat for marine organisms in a classroom aquarium are temperature, salinity and pH. Because most organisms can tolerate narrow ranges of temperature, salinity and pH, they are said to be limiting factors.

Salinity is the concentration of salts dissolved in sea water. It is usually expressed in parts per thousand (0/00) salinity. The salinity of water in the open ocean is about 35 parts per thousand (35 grams per 1000 ml of water).

Salinity is related to density and temperature. If a water sample is relatively free of suspended particles, then the density is directly related to the dissolved salts at a known temperature. Most marine organisms function best at 30 ppt or at a desnity of 1.025.

Temperature effects the rate at which all the reactions that comprise the life processes take place. Colder temperatures tend to slow down the body processes of cold blooded animals while higher temperatures tend to speed them up. Most organisms that can be successfully maintained in a classroom salt water aquarium can be kept at temperatures between 21^{o} to 24^{o} C.

pH is a measure of the relative degree of acidity and alkalinity of a substance. An acid is a substance that releases hydrogen ions (H^{+}) in solution while a base is a substance that releases hydroxyl ions OH^{-} in solution. The pH scale runs from zero to fourteen. A pH of seven is neutral. Any pH lower than seven is acid and any pH that is greater than seven is basic (alkaline). Most marine organisms function best in a pH range of 8 to 8.3.

TEACHER PREPARATION

Order or gather the materials in advance of this lesson.

Use Celcius thermometers for this lesson. Obtain hydrometers in the density range of 1.000 to 1.060. Urine hydrometers will be satisfactory. Caution students to use the thermometers and hydrometers with caution as they can easily be broken.

For the pH measurements, use either a pH indicator called a color comparator or p-Hydrion paper. Follow the instructions included with the comparator. Order a wide range p-Hydrion paper from 1 to 11 that is accompanied by both odd and even pH unit charts and a short range p-Hydrion paper with a pH range of 7.2 to 8.8.

ACTIVITIES

Obtain a water sample from the aquarium and place it in a clean graduated cylinder.

A. Water Temperature

1. Place the bulb of the thermometer underneath the surface of the water and when the column of liquid in the thermometer no longer moves, record the level of the liquid in degrees Celsius.

B. Water Salinity

1. Measure the density of the water with a hydrometer. Float the hydrometer in the column of water in the cylinder and read the density on the hydrometer at the water level. Read the bottom of the meniscus.

2. The hydrometer has been calibrated at $15^{o}C$. Use the Temperature Correction Table to convert the hydrometer value to the value corresponding to the temperature of the water.

3. Use the corrected density value to obtain the salinity of the water from the Salinity Conversion Table.

C. Water pH

Color Comparator Method

1. Remove the two test tubes from the comparator (either a box with colored windows or a color wheel). Rinse the test tubes with distilled water.

2. Fill the tubes with water from the aquarium to the line indicated on the tubes.

3. Add the proper amount of indicator solution to one of the test tubes. Follow the directions that accompany the comparator for the number of drops of indicator to be added.

4. Mix the solution to which the indicator has been added by swirling the tube and place both tubes in the comparator.

5. Compare the color of the tube with the colored windows in the comparator by holding the device against the light. Read the pH number under the window or through the hole of the color wheel that matches the color of the water sample to which indicator solution has been added.

p-Hydrion Paper Method

1. Obtain and tear off a 3 cm piece of wide range p-Hydrion paper and touch one end to the water sample. Keep the remainder of the strip dry.

2. Compare the color of the wet paper with the color scale provided with the p-Hydrion paper.

3. Read and record the approximate pH.

4. Obtain and tear off a 3 cm strip of short range p-Hydrion paper and touch it to the water sample.

5. Follow the directions given above to determine and record a more accurate measure of the pH of the water sample.

OBSERVATIONS AND QUESTIONS

1. What is the relationship between density and salinity?

2. Leave a hydrometer in the marine aquarium for several days and determine the salinity at regular intervals. What is the effect of evaporation on the salinity of the water?

3. What is the effect of algae growth on water density?

4. Determine the pH of the water at regular intervals. How does algae growth effect the water pH?

5. If any larger animal dies, take a water sample from near the animal to test for pH. What is the effect of decaying organic matter on the water pH?

LESSON NUMBER: 2

BRINE SHRIMP CAPERS

LESSON CONCEPT

Brine shrimp are useful in studying characteristics of living organisms.

COMPETENCY GOALS

1. The learner will demonstrate the ability to experiment.
2. The learner will demonstrate the ability to control variables.
3. The learner will demonstrate the ability interpret data.

OBJECTIVES

1. The learner will design and carry out investigations of the responses in brine shrimp using appropriate materials.
2. The learner will record observed information and make inferenses about the results of the investigations.

MATERIALS

For Preparation: containers for hatching brine shrimp: wide-mouth jars, small all-glass aquaria, glass baking dishes
distilled or aged tap water
non-iodized salt
balance

For Student Activities: (per team)

A. coverslip
cotton
microscope
slide

B. glass baking dish
flashlight

C. salt solutions: 0%, 5%, 10%, 20%, 30%, 40%, and 50%
vials
pipette
syracuse dish

D. vials
pipette
syracuse dish
3 temperature locations

E. Food: algae water, yeast and/or whole wheat flour
holding tanks for the brine shrimp

VOCABULARY

crustacean phototaxis optimum

BACKGROUND INFORMATION

The brine shrimp (Artemia salina) is a tiny crustacean found in salt lakes and provides an excellent food source for filter feeders and small carnivores in a marine aquarium. Brine shrimp may be purchased from pet shops, tropical fish stores and from biological supply companies.

To hatch the eggs, make a 10% solution of non-iodized salt water by adding 100 grams of non-iodized salt to 1000 ml of distilled or aged tap water. Aged tap water is prepared by leaving tap water uncovered for three days to allow the gaseous chlorine to escape.

Place the water in one or more wide mouth jars or containers with an air stone connected to an air pump. (See Temporary Holding Tanks in the introduction of this unit.) If an air pump is unavailable hatch the eggs in shallow glass baking dishes or large culture bowls to give a large surface to volume ratio.

Sprinkle about one-fourth teaspoon of eggs over the surface of the water in each container. At classroom temperatures the brine shrimp eggs should hatch in two days.

Use the hatched brine shrimp to feed filter feeders and small carnivores in your classroom marine aquarium. The brine shrimp can be removed from their containers with a long pipette or with a poultry baster and placed near the organisms in the aquarium.

TEACHER PREPARATION

Collect and age tap water in plastic buckets in advance ot this lesson. Order the brine shrimp eggs for hatching. Prepare the series of salt water solutions for the population counts: 0%, 5%, 10%, 20%, 30%, 40% and 50% by adding 0, 10, 20, 30, 40 and 50 grams of non-iodized salt to 100 ml of distilled or aged tap water for each respective concentration. Prepare copies of supplementary sheet 2.1.

STUDENT PREPARATION

Ask students to bring flashlights from home.

ACTIVITIES

A. Microscopic Examination

1. Place a few strand of cotton fibers on a clean glass slide.

Place a drop of water containing several brine shrimp on the slide and add a coverslip.

2. Examine the slide under the low power magnification. Try to locate a brine shrimp that is trapped in a cell formed by the cotton fibers.

3. Focus on an individual brine shrimp with the high power magnification and sketch it. Compare the anatomy of a brine shrimp with a crayfish and a shrimp.

B. Response To Light

1. Place brine shrimp and some water from their container into a shallow glass baking dish. Shine a flashlight over one end of the dish. Observe how the brine shrimp respond to the light.

2. Look up the terms photo- and -taxis. What is meant by phototaxis? Distinguish between positive and negative phototaxis.

C. The Effect Of Salinity On Hatching

1. Your teacher has prepared the following salt water concentrations: 0%, 5%, 10%, 20%, 30%, 40% and 50%. Obtain seven vials and label them with the salt concentrations. Count and place 50 eggs in each vial. Place the vials in an area where they will not be disturbed for two days.

2. Swirl and pour the contents of each vial into a separate syracuse dish. Count the number of hatched brine shrimp for each salt concentration and record the data in the Hatching Data Sheet, 2.1.

3. Prepare a histogram showing the percentage of eggs hatched in each salt concentration by plotting the data on the graph.

D. Response To Temperature

1. Choose the optimum salt concentration for hatching and then conduct a study on the effect of temperature on hatching.

2. Use a similar method that was used in Activity C but keep the salinity constant and vary the temperature.

3. Try locating the vials in an incubator, at room temperature and in the vegetable bin of the refrigerator. Place a thermometer with the vials to determine the temperature of each location.

E. Culturing Brine Shrimp

1. Try to keep the brine shrimp cultures alive by feeding. Brine shrimp will eat single celled algae, yeast and whole wheat flour.

2. Green algae water may be pipetted into their container. If yeast or flour is used, make a suspension by adding one-fourth teaspoon of yeast or flour to 100 ml of culture water. Pour the suspension into the brine shrimp container. As the water clears, more food can be added.

3. Once a week remove any sediment by pipetting it from the bottom of the culture container.

4. Mark the water level so that any water lost by evaporation may be replaced. Add only distilled or aged tap water.

OBSERVATIONS AND QUESTIONS

1. Sketch a drawing of a brine shrimp.

2. What anatomical features can you see?

3. What characteristics of brine shrimp relate it to other crustaceans?

4. Define phototaxis.

5. Are brine shrimp positive or negative phototaxic?

6. Which concentration of salt gave the highest rate of hatching? Look up the definition for the term optimum.

7. Under which temperature conditions did the brine shrimp eggs yield the highest hatching rate? The lowest?

8. Describe an experiment to find a suitable culture method for brine shrimp.

LESSON NUMBER: 3

CREEPY CRAWLERS

LESSON CONCEPT

Marsh periwinkles move up and down the blades of cordgrass with tidal flux.

COMPETENCY GOALS

1. The learner will develop skill in constructing simple equipment.
2. The learner will understand that all organisms exhibit behavior (response to stimuli).
3. The learner will demonstrate the ability to observe, measure, infer and interpret data.

OBJECTIVES

1. The learner will be able to identify the marsh periwinkle.
2. The learner will be able to draw conclusions about the marsh periwinkle's reaction to water levels.

MATERIALS

2 gallon glass tanks or 1 gallon jar
ruler
rubber tubing
pinch clamp
plastic bucket
stand to elevate bucket
4 periwinkles
data sheet (SC1, 3.2)
graph (SC1, 3.3)
medicine dropper
large rubber bulb (to fit glass tube of medicine dropper)

BACKGROUND INFORMATION

The marsh periwinkle, a mollusk, lives on cordgrass in salt marshes. They vary in length from 1.3 to 2.5 centimeters and are drably colored. Periwinkles feed on detritus (partially decayed salt marsh cordgrass) and algae that is deposited on the blades of the cordgrass as the tide recedes. The periwinkle are noted for their movement up and down the blades of cordgrass with the fluctuation of the tides.

TEACHER PREPARATION

Collect specimens of periwinkles attached to cordgrass. Make sure holding areas for these organisms have been set up before collecting them. Organize students into teams of four students per station.

STUDENT PREPARATION

1. Construct holding habitats according to the diagram on supplementary sheet SC1, 3.1.
2. Obtain a container for the habitat.
3. Tape a cm ruler in a vertical position onto the side of the container so that the zero end is at the bottom level.
4. Add sea water to a level of 5 cm.
5. Place the snails in the habitat.
6. Allow them to adjust to their new surroundings.
7. Set a 2 gallon bucket of sea water at a level higher than the habitat tank.
8. Obtain a rubber tube, pinch clamp, large rubber bulb and the glass tube from a medicine dropper.

ACTIVITIES

1. On the Marsh Periwinkle Data Sheet (3.2) record the heights of the snails when the water level is at 5 cm.
2. To make the siphon, run the rubber tube from the bottom of the bucket to the bottom of the holding tank. Install the pinch clamp but do not close it.
3. Remove the small bulb from the medicine dropper and replace it with the large rubber tube.
4. To begin the siphon, squeeze in on the large rubber bulb and insert the glass tube of the dropper into the aquarium end of the rubber tubing. Let out on the large rubber bulb and the suction should start the siphon. As soon as the water begins to flow, remove the dropper.
5. Allow the tank to fill to the 10 cm level before stopping the flow by closing the pinch clamp.
6. If the column of water in the rubber tube is not lost, the water level can be increased by just loosening the pinch clamp.

7. Slowly increase the water level by 5 cm increments and each time record the height of the snails on the data sheet (3.2).

8. Add the combined heights of the snails and divide by the number of snails to obtain an average height.

9. On the graph (3.3) plot the average snail height against the height of the sea water.

10. When the experiment is over, return the snails to their original habitat.

QUESTIONS

1. How is the movement of the marsh periwinkle related to water levels?

2. Did the periwinkle respond when the water level increased? How? Decreased? How?

3. Formulate a hypothesis about the periwinkle behavior.

LESSON NUMBER: 4

FIDDLER FOOD FINDER

LESSON CONCEPT

1. Fiddler crabs exhibit a response to the presence of food.
2. Fiddler crabs rely on their sense of chemoreception to find a source of food.

COMPETENCY GOALS

1. The learner will develop skill in constructing simple equipment.
2. The learner will demonstrate the ability to observe.
3. The learner will understand that all organisms exhibit behavior.
4. The learner will be able to develop and use graphs in a manner commensurate with his/her mental maturity.
5. The learner will demonstrate the ability to interpret data.

OBJECTIVES

1. The learner will accurately identify the physical characteristics of a fiddler crab.
2. The learner will be able to distinguish in writing which food(s) the fiddler crabs preferred.
3. The learner will be able to communicate by graph the results of the experiment.

VOCABULARY

chemoreception substrate arthropods

MATERIALS

fiddler crab maze
sand
fiddler crab
food assortment (meat, egg, fish, plants, salt marsh soil)
sheet of transparent plastic (pliable)
rulers
pencil
paper
salt water
watch with a second hand
shoebox

BACKGROUND INFORMATION

Fiddler Crabs, burrowing arthropods, prefer the drier portions of salt marshes on the Atlantic coast. The animals get their name from the single over-sized "fiddle-like" claw present on the male. The male uses the large claw for sexual display to attract the female crab. The female has two small claws. Fiddler crabs are noted for their quick movement in a sideways motion. Fiddler crabs feed by scraping organic matter from the substrate.

Fiddler crabs congregate in large numbers and dig holes above the tide line. If fiddler crabs are frightened, males lift the large claw and run sideways to their holes.

TEACHER PREPARATION

Collect enough fiddler crabs so that each team of students will have a crab. Duplicate copies of the activity sheets. Have students collect and bring to class shoe boxes (2 per team). Bring an assortment of food (meat, egg, fish, marine algae and salt marsh soil) to class for the experiment.

STUDENT PREPARATION

Collect shoe boxes and construct the Fiddler Food Preference Circle, supplementary sheet 4.1.

ACTIVITIES

A. Fiddler Food Preference

1. Place the Food Preference Circle in the bottom center of a shoe box.

2. Line the box with a sheet of plastic. Fold and tape the plastic in place so that it forms a smooth liner to the box.

3. Place different food items at each site on the circle. Each class team should use the same food items at each site so that class data can be pooled.

4. Each team should place its crab in the center of the circle.

5. Record to which food the crab moves.

6. As soon as the crab reaches the food, remove it from the food and return it to the center position. Repeat the experiment five times. Record your observations on the chalkboard. When all the teams have recorded their data, complete the information in Data Sheet 4.2.

7. Calculate the percentage of trials each food was preferred by:

$$\frac{\text{No. of occurences for food type}}{\text{Total number of occurrences}} \times 100 = _____\%$$

EXAMPLE: $\frac{\text{6 crabs preferred minced shrimp}}{\text{30 occurences}} \times 100 = 20\%$

8. Prepare a histogram of food preferences in fiddler crabs by using the graph on supplementary sheet 4.3.

QUESTIONS

1. Which food(s) did the crabs prefer?

2. Can we be sure that the crabs like these foods best? Why or why not?

3. How could this experiment be changed to obtain more accurate data?

B. Fiddler Crab Maze

1. Each team should construct a Fiddler Crab Maze according to the directions on Supplementary sheet 4.4.

2. Measure the distance from the center of the starting position to the center of position #1 to the nearest millimeter. Record this value on the Data Sheet 4.5.

3. Place the food item that was preferred by the crabs in the food preference experiment in position #1 in the maze. The food will be in full sight of the crab.

4. Place the crab in the starting position. Begin timing when the crab is placed in the starting position. Stop timing when the crab reaches the food. Record the time it takes for the crab to reach the food.

5. Repeat the above procedure with the same food item placed in position #2.

6. Calculate the rate by dividing the distance the crab travels to the food by the time it takes to get there.

7. Determine the average rate it takes for the crabs to locate the food in sight (position #1) and the hidden food (position #2).

QUESTIONS

1. Was there any difference in the rate between crabs getting to the food in position #1 and getting to position #2? Explain.

2. How do you suppose the crabs found the food when it was in position #1? Position #2?

3. How could we control this experiment to obtain more accurate data?

LESSON NUMBER: 5

COQUINA CURRENTS

LESSON CONCEPT

Coquina clams have incurrent and excurrent siphons.

COMPETENCY GOALS

1. The learner will demonstrate the ability to observe.
2. The learner will understand that each organism has special structures by which it adapts to its surroundings.
3. The learner will demonstrate skill in the use of instruments.

OBJECTIVES

1. The learner will be able to identify the incurrent and excurrent siphons of a coquina clam.
2. The learner will accurately describe the functions of the siphons of coquina clams.

MATERIALS

1 medicine dropper
1 hand lens
1 white-bottomed container (milk carton cut lengthwise)
1 coquina clam
sea water
dropping bottle of sea water colored with food coloring

VOCABULARY

siphon incurrent excurrent mollusk

BACKGROUND INFORAMTION

Coquina clams, bivalved, burrowing mollusks, are found on ocean beaches. Approxiamtely 19 millimeters in size, they vary in color. The shells are small, strong and minutely toothed. Coquina clams are filter feeders--water brought in through the incurrent siphon brings plankton as food. One siphon brings fresh oxygenated water and as it passes over the gills, the oyxgen is removed. The water with carbon dioxide is released through the excurrent siphon.

Coquinas can be found from Delaware to the Gulf of Mexico and are one of the few inhabitatns of the surf zone on sandy beaches. Coquinas burrow when waves recede and emerge with the next surge. When found, they are usually abundant (hundreds of thousands per square yard). For people with patience and perserverance they make a delicate chowder.

TEACHER PREPARATION

Collect coquina clams no more than one or two days in advance and store in a temporary holding tank. Have several students gather and distribute the equipment for each student.

Prepare the colored sea water by half filling dropping bottles with fresh sea water. Add 1-3 drops of a dark food coloring (blue or green) to the water to obtain a distinct color.

STUDENT PREPARATION

Collect and clean milk cartons and cut them in half lengthwise.

ACTIVITIES

A. Coquina Currents

1. Fill the milk carton with 300 milliliters of sea water.
2. Place the coquina clam in the container.
3. Allow enough time for the clam to relax (i.e. begin to open).
4. Fill the dropper with food coloring mixture.
5. Carefully place the tip of the dropper under water near the siphon of the coquina clam and gently squeeze the bulb of the dropper to emit some of the solution. What happens?
6. Draw a diagram of the clam and describe what happened. On the diagram, show which siphon was incurrent and which siphon was excurrent.

QUESTIONS

1. Define the words siphon, incurrent and excurrent.
2. What are the functions of the siphons?
3. Discuss how clams obtain oxygen from water.
4. What adaptations would people need to live under water?

ALTERNATIVE ACTIVITIES

Using the procedure described, students can investigate currents created by other marine organisms such as fish, shrimp, starfish and crabs. Through these investigations students may determine different aspects of movement and respiration.

SOURCES

Outdoor Biological Instructional Strategies. "Water Breathers." Lawrence Hall of Science, University of California, Berkley, California.

Gosner, Kenneth T. A Field Guide To The Atlantic Seashore. Boston: Houghton-Mifflin Co., 1979.

LESSON NUMBER: 6

DIG A LITTLE DEEPER

LESSON CONCEPT

Mole crabs burrowing is directly related to moisture, light and substrate particle size.

COMPETENCY GOALS

1. The learner will demonstrate the ability to control variables.
2. The learner will demonstrate the ability to observe.

OBJECTIVES

1. The learner will be able to correctly identify mole crabs.
2. The learner will be able to describe the factors affecting mole crab burrowing.

MATERIALS (Per group)

4 plastic shoe boxes
sifters of different meshes
mole crabs
substrate (coarse and fine sand and mud)
flourescent lamp
petri dishes
data sheet
sea water

BACKGROUND INFORMATION

Mole crabs resemble eggs when their legs are folded underneath. They live on sandy beaches at the water line, exposed to wave action. A mole crab burrows quickly into the loose sand. Mole crabs are gregarious, found in large numbers. The females are about 2.5 cm and are larger than the male, about 1 cm in length. Mole crabs live on plankton which they filter from the sea.

TEACHER PREPARATION

Gather materials prior to class. Divide the class into three groups. Duplicate copies of Activity Sheet 6.1 for each student.

STUDENT PREPARATION

Sifters may be constructed by removing both ends from food cans and taping different meshes of hardware cloth to the bottoms of the cans with duct tape.

ACTIVITIES

A. Experiment #1

1. Obtain 2 plastic shoe boxes; label #1 and #2.
2. Half fill the containers with moist medium grain sand. Place the box in bright light.
3. Use five mole crabs for this experiment but use one crab at a time. Place one crab in the box and use a watch with a second hand to time how long it takes for the crab to disappear.
4. Begin timing just as soon as the crab is placed on the sand and stop timing when the crab's body disappears entirely. The stalked eyes may still be visable.
5. Repeat the procedure with the remaining four crabs and record the data on the Supplementary sheet SC1, 6.1.
6. Now place the containers in an area of subdued light such as a storage room. Repeat the experiments in a mimimun of light; just enough light to see to perform the experiment.
7. Record the times for the five crabs to disappear in subdued light.

B. Experiment #2

1. Half fill four plastic shoe boxes with medium dry sand.
2. Omit any water from box #1. In the remaining boxes, pour varying amounts of sea water to obtain a gradient from #2 with only slightly moistened sand to #4 with very moist sand.
3. Use five crabs for this experiment. Time how fast it takes each crab to disappear in each box. Record this data in the Supplementary data sheet.

C. Experiment #3

1. Fill box #1 with find mud; #2 with medium moist sand; and #3 with coarse grain moist sand.
2. Again use five crabs and time and record how long it takes each crab to disappear in each box.

QUESTIONS

1. What are the variables in the three experiments?

2. What factors had to be controlled in each experiment?

3. Under which light condition did the crabs dig the most rapidly? How do you account for this response?

4. Under which moisture condition did the crabs dig the fastest? The slowest? Explain this behavior.

5. In which texture did the crabs dig the fastest? The slowest? Explain this response.

LESSON NUMBER: 7

SNAIL RACE

LESSON CONCEPT

Mud snails use chemoreception in locating food.

COMPETENCY GOALS

1. The learner will understand that all organisms exhibit behavior.
2. The learner will demonstrate the ability to observe.
3. The learner will demonstrate the ability to interpret data.

OBJECTIVES

1. The learner will be able to define chemoreception and how it works.
2. The learner will be able to identify and give characteristics of the mud snail.

MATERIALS

mud snails (1 per student)
sea water
plastic sheeting (lining for box)
1 plastic sweater/shoe box
medicine dropper
plastic food containers
shrimp or crab meat (fresh or frozen)
glass vials with stoppers
motar and pestle

VOCABULARY

chemoreception
invertebrate
gastropod
omnivorous
mollusk

BACKGROUND INFORMATION

Mud snails are mollusks that make their homes in mud flats bordering sounds and bays. They belong to the class Gastropoda, meaning stomach footed. Mud snails are drably colored, usually black to olive, resembling the color of the silt in which they live.

Mud snails occur in large numbers in some places, crawling over the surface of the mud and silt. They are omnivorous, feeding on algae, marine worm larvae, dead fish and shrimp. They are able to locate food by chemoreception, detecting food odors in their environment. Sensory units in the tentacles respond to molecules of food in the water. The animals move in the direction of the food.

TEACHER PREPARATION

Gather equipment prior to class. Secure bits of shrimp and crab prior to the class day. Place a piece of the shrimp or crab and a small amount of water into the motar and grind with the pestle. Place the ground solution in a closed vial or test tube with a rubber stopper.

ACTIVITIES

A. Mud Snail Feeders

1. Have a student distribute mud snails, containers and sea water to each student.
2. Place the snail in a container of sea water.
3. Allow enough time for the snail to relax (i.e. begin to open and move around).
4. Fill the dropper with shrimp or crab extract.
5. Carefully place the tip of the dropper near the snail and gently squeeze the bulb of the dropper to emit some of the solution. What happens.
6. Record your observations of the snail behavior in locating food.

QUESTIONS

1. What behavior did the mud snail exhibit in locating food?
2. Devise and conduct an experiment to find other foods mud snails will eat? Record your results.

B. Mud Snail Racers

1. Use a plastic shoe box or a pasteboard box lined with plastic sheeting to make a snail runway. Add enough sea water to cover the snails.
2. Each member of a team should choose a snail.

3. Wipe the shell dry with a piece of paper towel and apply a spot of paint or nail polish to the shell for identification. Each snail should have a different color. Allow the paint to dry.

4. Place some food at one end of the runway.

5. Place all of the snails at the starting line at the opposite end of the runway.

6. Determine which snails reach the food first, second and etc.

QUESTIONS

1. Which snail came in first? Second?

2. Why do you think these snails won the race?

3. Formulate a hypothesis about what characteristics of snails allow them to move faster.

4. Devise and conduct an experiment to test your hypothesis. Record the results.

LESSON NUMBER: 8

PICTURE THAT

LESSON CONCEPT

Marine algae may be mounted and preserved for classroom studies.

COMPETENCY GOALS

1. The learner will understand that a community must have an energy source.
2. The learner will demonstrate the ability to classify.
3. The learner will demonstrate skill in the use of instruments.

OBJECTIVES

1. The learner will be able to describe the procedure for preparing herbarium mounts.
2. The learner will be able to classify algae.

MATERIALS

plant press
shallow pans or trays
wax paper
newspaper
algae identification aids
plastic bags
probes
water color paper
assorted algae
white paper (tags)
scissors
cellophane or contact paper

BACKGROUND INFORMATION

Green plants convert solar energy to food during the process of photosynthesis. Photosynthesis can only occur if the plants contain chlorophyll. Sea lettuce, a green algae contains chlorophyll and stores food as starch. Fucus, a brown alga contains a brown pigment as well as chlorophyll. Red algae contain a red pigment in addition to chlorophyll.

TEACHER PREPARATION

Algae can be easily mounted for classification. Collect the algae specimens and place them in a plastic bucket. The lesson should begin with mounting and pressing at the end of the week and drying over the weekend.

STUDENT PREPARATION

Students need to bring to class newspaper, waxpaper, plastic bags and cellophane wrap.

ACTIVITIES

A. Pressed Algae

1. Add water to a shallow flat pan to a depth of 1.5 cm.
2. Place the algae in the pan and flatten it out.
3. Select a portion of the algae for the mount and slip a piece of water color paper under the specimen. Position and straighten the specimen into place.
4. Gently raise the paper out of the water by grasping the corners of the paper.
5. Place the mounted algae into a plant press. Alternate in layers the newspaper, algae mount, wax paper, newspaper. Perform this procedure for each specimen, always taking care to apply a sheet of wax paper directly on top of the algae.
6. Place the press in a warm, dry place.
7. Change the newspaper every 6-12 hours or as often as possible.
8. When the specimen mount is dry, cover it with contact paper or cellophane.
9. Be prepared to aid students in identifying their specimens.
10. In an 8" x 10" index card, have the students identify each specimen with the following information:

KINGDOM:
PHYLUM:
WHERE IT WAS FOUND:
COMMON NAME:
DESCRIPTION:

LESSON NUMBER: 9

THE BEST OF ENEMIES

LESSON CONCEPT

Starfish are primary predators of scallops.

COMPETENCY GOALS

1. The learner will understand that all organisms exhibit behavior.
2. The learner will demonstrate the ability to observe and infer.

OBJECTIVES

1. The learner will be able to describe the behavior of scallops and starfish.
2. The learner will be able to determine which organisms pose a threat to scallops.

MATERIALS

sea water
scallops
mud snails
small aquarium or other container
starfish
blue crab
coquina clams

BACKGROUND INFORMATION

Starfish use their water vascular system to open shells of scallops, clams and oysters. The starfish arches over the shells with the rays bent downward. The tube feet of the starfish pull the scallop apart. The starfish pushes its stomach out from a small opening in the center of the lower side. The stomach squeezes through the small opening between the scallop shells. Enzymes, secreted by the stomach, digest the tissue of the scallop.

TEACHER PREPARATION

Collect live scallops, starfish, blue crabs, mud snails and other marine organisms. Gather needed materials.

ACTIVITIES

A. Feeding Habits

1. Place a scallop in the container filled with sea water.
2. Let the scallop relax (shell opened).
3. Place the starfish in the container with the scallop.
4. Record your observations.
5. Remove the starfish and let the scallop relax again.
6. Place another organism in the tank.
7. Record your observations.
8. Try an assortment of organisms and record your observations.

QUESTIONS

1. How did the scallop know the starfish was present?
2. Why did the scallop react as it did?
3. How do you account for the scallop's reactions to each of the other organisms?
4. How did the scallop move?

ALTERNATIVE ACTIVITIES

Check scallop reactions to the following stimuli:

1. Direct a bright light into a dark or semi-dark aquarium.
2. Place a vibrating tuning fork on the surface of the water.
3. Tap on the side of the tank.

LESSON NUMBER: 10

IT LOOKS GREEN TO ME

LESSON CONCEPT

The pigments in Sea lettuce, Ulva, can been separated by paper chromatography.

COMPETENCY GOALS

1. The learner will demonstrate the ability to experiment.
2. The learner will demonstrate skill in the use of instruments.

OBJECTIVES

1. The learner will demonstrate his/her knowledge of paper chromatography by recalling the steps to the procedure.
2. The learner will be able to list the equipment necessary for separating plant pigments by paper chromatography.

MATERIALS

sea lettuce
strip chromatography or filter paper
mortar and pestle
test tube with fitting cork
acetone solvent (9 parts petroleum ether and 1 part benzene)
large paper clip
fine sand
test tube rack

VOCABULARY

chromatography	pigments	chlorophyll	xanthophyll
photosynthesis	chloroplasts	carotene	

BACKGROUND INFORMATION

Photosynthetic plants contain a variety of pigments which may be extracted by grinding plant tissue in a solvent such as acetone. The pigments in the extract may be separated by a technique called paper chromatography. Some pigments that may be found in marine algae are: chlorophyll a (forest green), chlorophyll b (yellowish green), xanthophyll (light yellow), carotene (dark yellow) fucoxanthin (brown), phycoerythrin (red), and phycocyanin (blue).

TEACHER PREPARATION

Acetone and petroleum ether are extremely volatile chemicals. Windows should be open for ventilation. There should be enough solvent to fill a test tube (medium size) with a depth of about 1 cm. per student team. Have the equipment ready prior to the class period.

STUDENT PREPARATION

Students should collect and bring to class sea lettuce, making sure to keep it wet until it can be used in this investigation.

ACTIVITIES

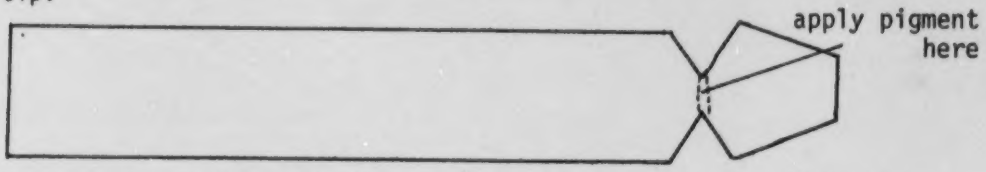
A. Sea Lettuce Pigments

1. Rinse the sea lettuce with tap water and blot it with paper towels to remove any excess water.

2. Add a little fine sand to the mortar along with the dry sea lettuce. Add a few drops of acetone and grind the sea lettuce with the pestle. Continue to add sea lettuce and acetone as needed to obtain a rich green extract.

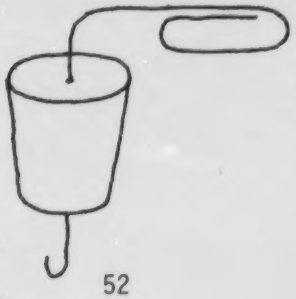
3. Place a square of cheese cloth over a beaker and filter the sea lettuce extract.

4. Cut a strip of filter paper 2 cm. wide by 12 cm. long. Tape one end and cut notches on both sides about 1.5 cm. from the tip.



5. With a fine point paint brush, apply the pigment extract in a thin line between the notches on the paper strip. Blow on the pigment line to dry it. Continue to apply the extract until a dark concentrated pigment line is attained.

6. Open one end of a paper clip and thrust it through the center of the cork. Leave the remainder of the paper clip as a handle. With pliers, bend the lower end of the paper clip to form a hook.



7. Add the solvent mixture (9 parts petroleum ether, 1 part benzene) to the large test tube to a depth of 1 cm. Place the tube into a rack or beaker for support.

8. Attach the paper strip to the paper clip hook and gently lower the tapered end into the solvent. CAUTION: Do not allow the solvent to come in contact with the line of pigment extract.

9. Fit the cork in the mouth of the test tube and observe the pigments separate along the paper strip. This record of separated plant pigments is called a chromatogram.

10. Try to identify the pigments found in sea lettuce.

B. Other Algae Pigments

1. Repeat the above procedure with other types of algae and determine what pigments are present.

2. If any red color is apparent, run a second chromatogram in which a little acetic acid has been added.

QUESTIONS

1. How many different pigments did you find? Name them.

2. When observing sea lettuce green is the only visible pigment. Why?

3. If so many plants have the same pigments, how can you explain the variety of colors and shades in plants?

4. Perform a library research to find which plant pigments are water-soluable and which are not water-soluable. Which are contained in plastids and which are not?

LESSON NUMBER: 11

STARFISH STRATEGIES

LESSON CONCEPT

Starfish exhibit unique behavior.

COMPETENCY GOALS

1. The learner will understand that a community is made up of interacting populations.
2. The learner will understand that each organism has special structures by which it adapts to its surroundings.
3. The learner will demonstrate the ability to experiment.

OBJECTIVES

1. The learner will describe starfish behavior.
2. The learner will be able to list factors affecting starfish behavior.

MATERIALS

plastic or glass container
sea water
starfish
clam
pencil
pieces of oyster, clams or scallops
paper

BACKGROUND INFORMATION

Starfish are members of the phylum Echinodermata, which means "spiny-skinned." The skeleton lies just beneath the epidermis (outer covering). The internal skeleton is called an endoskeleton. Starfish have radial symmetry; the arms or rays stick out like spokes in a wheel. On the bottom of each arm are hundreds of tube feet which act as suction cups. The tube feet are connected to a water vascular system. A sieve plateon top of the starfish is the entry for water into the vascular system. At the tip of each arm is an eyespot that is sensitive to light. If a starfish should lose an arm, it is able to grow another one through the process of regeneration. The mouth is on the bottom of the starfish in the center of the arms.

TEACHER PREPARATION

Gather materials and set up the experiment prior to the class period.

ACTIVITIES

A. Starfish Strategies

1. Have a student place the starfish on its back.

2. Record the length of time it takes the starfish to turn over. Record your observations of starfish movement.

3. Write a brief description of how the starfish turned itself over.

4. Locate the following external characteristics:

   a. water sieve plate
   b. mouth
   c. eyespots
   d. tube feet

5. Feed the starfish pieces of fresh oysters, clams or scallops OR place an oyster, clam or other mollusk in the tank with the starfish.

6. Write a description of the starfish feeding.

QUESTIONS

1. How does the starfish move?

2. What is meant by radial symmetry and how is this exhibited in the starfish?

3. What is meant by regeneration?

LESSON NUMBER: 12

CRAB BEHAVIOR

LESSON CONCEPT

Blue crabs exhibit territorial behavior.

COMPETENCY GOAL

The learner will understand that all organisms exhibit behavior.

OBJECTIVE

The learner will be able to observe the territorial behavior of blue crabs.

MATERIALS (per team)

large plastic box (cat litter box, etc.)
empty half gallon milk cartons
sand or shells
sea water
colored tape or paint(3 colors)
wooden forceps (optional)
chopped fish

BACKGROUND INFORMATION

Blue crabs belong to the phylum Arthropoda and class Crustacea. Arthropod characteristics are jointed appendages, an exoskeleton and a segmented body. Blue crabs are swimmers with the last pair of legs flattened and adapted for swimming. Blue crabs are scavengers and prefer brackish water of sounds and bays. The female lays eggs in the summer and they remain attached to her. The eggs hatch into larvae in two weeks. The young crab goes through several molting stages before it resembles the familiar adult.

TEACHER PREPARATION

Collect suitable containers, crabs and fish for crab food before beginning the activities.

STUDENT PREPARATION

Each team of students should collect three small live crabs for the activities. Collect and thoroughly clean half-gallon cardboard milk cartons for crab refuges.

ACTIVITIES

1. Students should work in teams of four. Each student should prepare a log in a notebook in which to record observations of crab behavior. A suggested log could be organized as follows:

LEGEND		
Color	Crab No.	Sex
	1	
	2	
	3	

DATE	SET-UP OR STIMULUS	RESPONSE

2. Prepare a crab habitat by covering the bottom of a plastic box with sand or crushed shell fragments.

3. Add sea water to a depth of 7-10 centimeters.

4. Mark the water level with tape and add distilled or aged tap water to the habitat when the level drops from evaporation.

5. Wash and rinse two 1 quart pasteboard milk cartons. Cut each milk carton in half and discard the top half.

6. Cut the bottom half of each carton along the diagonal to obtain two tent shaped structures.

7. Place three tent-shaped refuges around the inside perimeter of the habitat.

8. Obtain three small blue crabs. CAUTION: Pick the crabs up by clasping them at the top joint on the right back leg with the forefinger and thumb or with a pair of wooden forceps.

9. Label each crab by drying a patch on the carapace (dorsal surface) with a paper towel and adding a piece of colored tape or a spot of paint. EXAMPLE: Red - crab #1, blue = crab #2, and green = crab #3. Record the color and sex of each crab.

10. Place the three crabs in the center of the habitat and record what happens. Record which crabs go to which refuges.

11. Let the crabs adjust to their new habitat overnight before carrying out any further studies.

12. Feed the crabs on small pieces of fish every other day. A fish may be kept in the freezer and slices removed as needed. Do not leave food in the container after a two hour interval. Keep the water level at the marked line to prevent the salt from becoming too concentrated. Completely change the water once a week.

13. Design and carry out controlled experiments to study crab behavior in the following situations.

    What is the response when:

    a. Food is placed in the center of the habitat?

    b. One refuge is removed? Two are removed?

    c. When the refuges are different colors?

    d. When a female is introduced into a tank with two established males?

    e. Other situations that you devise?

14. Keep a record of all experimental situations and crab behavior hibited exhibited in response to each different situation.

QUESTIONS

1. Did each crab select a refuge?

2. Did crabs continue to use the same refuge?

3. What happened when one refuge was removed? When two were removed?

4. Did you see any signs of agonistic behavior? Describe them. Under what circumstances were these behaviors demonstrated?

5. Did you see any evidence of dominance among the crabs? Explain.

6. How does size effect crab behavior?

7. How does sex effect crab behavior?

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Dare County Board of Education
Manteo, North Carolina

Care and Maintenance

This series describes how to care for and maintain animals and plants in your classroom. The authors are Carol D. Hampton and Carolyn H. Hampton, Professors of Science Education, East Carolina University, Greenville, North Carolina.

A Saltwater Aquarium

Bring the sea to your classroom by setting up a saltwater aquarium. While a marine aquarium is not as easily maintained as a freshwater aquarium, it is not a difficult task. If students follow instructions carefully, they will develop new skills and experiences and will soon be observing marine organisms in their own miniature ecosystem. In a class where a marine aquarium is maintained, student interests progress from casual observation, to studying feeding and behavior patterns, to taking responsibility for maintaining the tank and organisms.

In the ocean, water composition is quite stable because of the vastness and ability of seawater to dissolve and dilute water substances. Water in any given area is constantly circulated by tides, currents, and wave action. The key to a successful aquarium is maintaining good water quality.

Selecting a Tank

Use an inert tank of all glass or Plexiglass construction. A recessed ridge on which a glass or Plexiglass lid can rest will allow splashed water and condensation to drip back into the tank. Tanks of 75 to 110 liter (L) capacity are recommended. Smaller tanks do not allow for a variety and a good balance of organisms. Two 75 L tanks can hold more animals and provide more ecological niches than one 150 L tank. If one tank becomes contaminated, a second one can function while the first is cleaned.

Filtration System

Marine organisms (especially fish and motile invertebrates) produce a lot of waste material consisting of ammonia, urea, and carbon dioxide (CO_2). Ammonia is of greatest concern because it is toxic in relatively low concentrations.

There are two basic types of filtration: biological and mechanical. The essential filter for a marine aquarium is the undergravel filter, also called a biological filter because it relies on bacteria. As soon as the tank is set up, nitrifying bacteria and other microorganisms attach to the gravel and filter substrate surfaces. The microbes extract waste products and decaying matter from the water as it filters through the gravel. Ammonia and urea are converted to less toxic compounds called nitrites and finally to end products called nitrates. Nitrates, while still toxic, are only lethal at high concentrations. Green algae take up the nitrates and convert them into plant biomass. Nitrates also may be removed by a mechanical filter. (See Figures 1 and 2.)

A mechanical filter is not an absolute necessity. In conjunction with a subgravel filter, it will improve the quality of the water by removing particulate matter and keeping the dissolved oxygen concentration high. Usually this type of filter is a box attached to the outside of the tank. The water moves down through a layer of polyester fiber which filters out suspended particles and then moves through a layer of activated charcoal which adsorbs organic molecules. This type of filter in time becomes a biological filter, as nitrifying bacteria attach to the fibers.

Both types of filters must be attached to an air pump to make them operate. For 75 L tanks or larger, two undergravel filters are needed. If a mechanical filter is used, one is sufficient.

Water

Water for the aquarium may be either natural seawater or a medium made from synthetic sea salts. If you are located near the coast, marine organisms you collect will survive well in the water from their collection site. Sea water near the shore has a tendency to be polluted. Collect the water from a rock jetty or wade out into deeper water at high tide. Transport the water in plastic buckets. A good practice is to collect extra water to store for making

Figure 1. Mechanical Filter

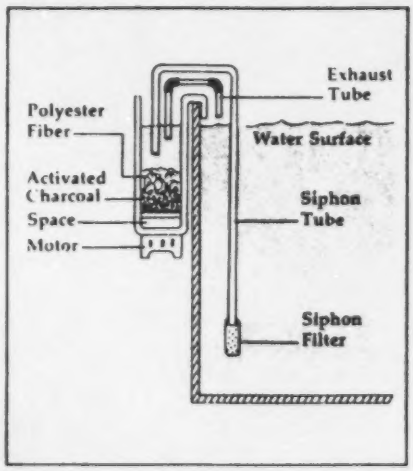
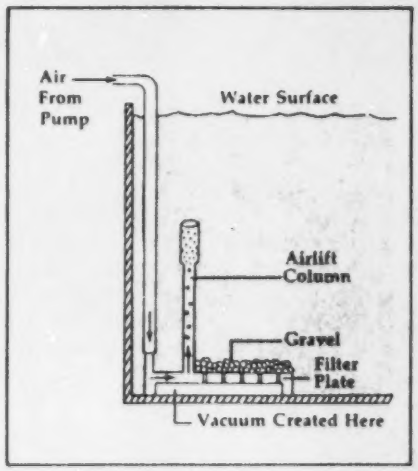


Figure 2. Biological Filter



water changes in maintaining the aquarium. Store the buckets in a darkened place and tighten the lids to prevent algae and other unwanted contaminants from growing. The quality of the water improves with storage. Before using natural seawater, filter it through a funnel packed with polyester fiber.

You can make synthetic seawater by mixing prepackaged salts and minerals with distilled or aged tap water. Before using tap water, leave it in an open plastic bucket for three days to allow the chlorine to escape. For best results, use a well-known sea salts product from a reputable supplier. Beware of off-brand products at the pet stores.

Bottom Material

Good materials to use as a substrate are calcareous gravel, limestone pebbles, coquina shells, or crushed coral. Slow dissolution of the calcium carbonate in shells and other limestone materials will help stabilize the pH of the water. Never use silaceous gravel, sand, or colored pebbles sold in pet stores. Be sure the particle size is greater than the holes in the subgravel filter.

Run freshwater over the bottom material in a plastic dishpan or bucket to clean it. Stir the material so dirt and organic debris float to the surface. As the heavy particles settle, pour off the floating material. Continue this procedure until the water remains clear when the gravel or shells sink to the bottom.

Setting up the Aquarium

Place the aquarium tank on a sturdy level surface. Select a location out of direct sunlight to prevent excessive algal growth. Never move a tank once it has any substrate and water in it or you will loosen the seams.

Install the subgravel filter connecting air hoses and an air pump according to the manufacturer's directions. Cover the filter with 5 to 7 centimeters (cm) of substrate material.

Decorate the seascape with pieces of coral, dried sea shells, and seafans. If you use rocks, be sure they have no holes, or have holes only large enough to permit recovery of animals that might hide in them and die. Soak seascaping materials in seawater for 48 hours before placing them in the aquarium. Do not use metal objects or metal containing rocks because they may add toxic metallic ions to the water.

Place a shallow saucer on the substrate and fill the tank 2-3 cm from the top. Pour water onto the saucer to prevent gouging out the substrate material. With a wax crayon or piece of masking tape, mark the water level on the outside of the tank. Install the outside mechanical filter, if one is used. Turn on the air pump and adjust the valves. The bubbles should rise rapidly but separately through the tubes of the subgravel filters.

System Stabilization

Let the aquarium system operate for at least three days before adding any organisms. Add one hardy organism for a one-week period, then add others. This procedure will help build up nitrifying bacteria in the undergravel filter and stabilize the physio-chemical environment. If it is not possible to condition the tank with a single organism, then let the aquarium stabilize for two weeks before adding a full population.

Stocking the Aquarium

In a classroom aquarium where temperature is difficult to regulate, the best specimens to maintain are those from the Middle Atlantic and the Gulf states

Figure 3.

Feeding Schedule

Recommended Organisms	Food	Schedule
Carnivorous Invertebrates Crabs, horseshoe crabs, starfish, brittle stars, mantis shrimp, moon snails	Feed chopped fish, small minnows, shrimp, earthworms, white worms, bits of lean beef placed at or under the animal.	Once/week
Sea anemones, coral polyps	Crush food with a little sea water into a watery paste. Pipette over the tentacles and polyps.	Three times/week
Filter-Feeders Barnacles, scallops, clams, hydroids, sponges, marine worms, sea squirts	Feed finely powdered fish food, *Daphnia*, freshly hatched brine shrimp, algal flagellates.	Three times/week
Herbivorous Species Sea hares, sea urchins, turbo snails	Feed natural growth of algae in tank, small pieces of lettuce or spinach.	Once/week
Carnivorous Fish Small fish such as killifish, sculpins, sea robbins	Feed dry fish food. Feed living brine shrimp or *Daphnia*.	Daily Two times/week
Scavengers Fiddler crabs, hermit crabs, cleaning shrimp, sand dollars, mud snails, flounder, pipefish	These species will aid in cleaning the aquarium of dead and decaying materials.	

(North Carolina to Texas). These specimens tolerate a temperature range of 18° to 21° C. Most biological supply houses advertise a composite of marine organisms for classroom aquaria. If you live near the coast, collect your own specimens. Thoroughly clean and rinse two milk cartons. Cut off the tops and arrange the cartons in a large ice chest with seaweed in the bottom of each carton. Fill the cartons with seawater to just below the surface of the seaweed. Add one to three invertebrate specimens to each carton. Be careful not to submerge them in water. The most common reasons for specimens not surviving transportation are overcrowding and lack of oxygen. The wet seaweed will keep specimen's respiratory surfaces moist. If the animals are not completely covered with water, more oxygen will spread across their respiratory surfaces. Place fish in a carton with just enough water to cover them. Collect specimens that are less than 5 cm in diameter. Do not pack predators with prey nor active organisms such as crabs with delicate animals. The biomass carrying capacity of a tank depends upon a number of factors including the efficiency of the filtering system and the metabolic rates of individual organisms. A good rule of thumb is about 18 to 20 animals per 75 L tank.

Acclimatizing the Specimens

Float the bags or cartons holding the animals in the aquarium. Add a little water from the aquarium to the bags every 15 minutes. If the animals act nervous or contract, stop and wait before adding water more slowly. When the water temperature in the containers equals the aquarium's, remove the specimens with a dip net or with gloves and place them in the aquarium.

Feeding Rules

1. Cut off the power supply to the filters so small food particles will not filter out of the aquarium.
2. Do not give more food than can be eaten in one to two hours.
3. Keep a few scavenger animals to help clean up excess food. (See Figure 3.)

Salt Water Aquarium Maintenance Checklist*

Daily	Weekly	Monthly
___ Adjust pump to run smoothly	___ Check water level	___ Replace 1/4 volume of sea water
___ Unclog air lines	___ Check salinity	___ Rinse polyester fibers
___ Assure airstones deliver tiny, even bubbles	___ Check pH	___ Change activated charcoal
___ Remove any dead organisms	___ Clean algae off inside walls	___ Oil filter pump motor
___ Remove any excess food	___ Gently stir up bottom debris	
___ Check water temperature	___ Change animals' diet	
___ Wipe salt off top and sides		
___ Check list of organisms to see if any are missing		

Figure 4.

Maintenance

Light. Do not expose the aquarium to direct sunlight. Excess light will cause undesirable algal growth and high temperatures. Diffuse light from a north or east facing window is best. If the area is exceptionally dark, use an aquarium hood with fluorescent lights.

Temperature. Extreme body temperature changes lead to stress, burrowing, dormancy, disease, and perhaps death of the animals. Keep the aquarium at 21° to 24° C.

Salinity. The salinity (salt content) should be kept at 30 parts per million or a hydrometer reading of 1.025. Once the aquarium is working and the water level is marked, add distilled or aged tap water to keep the water level stabilized. Never add more seawater; this increases the salinity. A glass cover over the aquarium will retard the rate of evaporation.

pH. The pH should be kept between 8.0 and 8.3. You can order a simple test kit from a biological supply house for this purpose. Calcareous shells and a natural growth of algae will help stabilize the pH. If the pH becomes too acid or falls below 8.0, remove a cup of aquarium water, add one teaspoon of bicarbonate of soda, mix well, and pour it slowly into the tank. If the water is still acid the next day, repeat the procedure until the water is the proper pH.

Water Changes. Make a partial water change once a month to dilute built-up wastes, replenish trace elements, and help maintain alkalinity. Siphon off one-fourth of the tank's volume and replace it with fresh seawater.

Remove the mechanical filter once a month. Rinse the polyester fibers in fresh, aged tap water and replace the activated charcoal. Be sure to rinse the new charcoal to remove dust particles that could cloud the water.

Most detritus (partially decayed organic matter) will be drawn into the gravel where bacterial action will break it down. However, with time, some debris may accumulate on the substrate. Periodically stir and circulate this material so filter feeders use it. Remove large, accumulated materials with a kitchen baster. Each week, scrape algae from the inside aquarium walls with a plastic aquarium scraper. Encourage children to keep a log of their organisms and sources of food. This will be useful information in planning the composition of organisms for future aquaria. The maintenance checklist may be posted near the aquarium with a list of the organisms. (See Figure 4.)

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*Adapted from Crenshaw, Neil. *Starting and Maintaining a Marine Aquarium.* Florida 4-H Marine Program, Florida. 1979.

NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

AND COMMUNITY DEVELOPMENT

DIVISION OF MARINE FISHERIES

P. O. Box 769

MOREHEAD CITY, NC 28557

APPLICATION FOR PERMIT TO COLLECT MARINE AND ESTUARINE ORGANISMS FOR SCIENTIFIC PURPOSES

DATE _____

NAME _____ INSTITUTION _____

ADDRESS _____ POSITION _____

_____ EDUCATION _____

PURPOSE OF COLLECTIONS: _____

_____

_____

_____

_____

METHODS: _____

_____

_____

SPECIES: _____

_____

WATER BODIES AND COUNTIES: _____

_____

_____

TIME OF COLLECTIONS: _____

_____

I have read the restrictions for issuance of this permit reprinted on the reverse side and agree to abide by them and any other restrictions which may be imposed.

_____

Signature

The permit will be subject to the following general conditions:

1. The collections shall be used for scientific or educational purposes only; shall be dedicated to public benefit; and shall not be used for commercial profit.

2. This permit may be used only by the person to whom it is issued.

3. That the permittee furnish this office a summary of the material collected under this permit no later than January 15 following the year the permit is in effect.

4. This permit shall immediately terminate upon violation of any of the conditions herein contained.

Measured density at 15°C	TEMPERATURE CORRECTION TABLE																				
	0°	1°	2°	3°	4°	5°	6-10°	11°	12°	13-17°	18°	19-21°	22°	23°	24°	25°	26°	27°	28°	29°	30°
1.000	1.000	1.000	.999	.999	.999	.999	.999	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.002	1.002	1.002	1.002	1.003	1.003	1.003
1.001	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.001	1.002	1.002	1.002	1.003	1.003	1.003	1.003	1.004	1.004	1.004
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1.011	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.011	1.011	1.012	1.012	1.012	1.013	1.013	1.013	1.013	1.014	1.014	1.014	1.015
1.012	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.011	1.012	1.012	1.013	1.013	1.013	1.014	1.014	1.014	1.014	1.015	1.015	1.015	1.016
1.013	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.012	1.013	1.013	1.014	1.014	1.014	1.015	1.015	1.015	1.015	1.016	1.016	1.016	1.017
1.014	1.013	1.013	1.013	1.013	1.013	1.013	1.013	1.013	1.014	1.014	1.015	1.015	1.015	1.016	1.016	1.016	1.016	1.017	1.017	1.017	1.018
1.015	1.014	1.014	1.014	1.014	1.014	1.014	1.014	1.014	1.015	1.015	1.016	1.016	1.016	1.017	1.017	1.017	1.017	1.018	1.018	1.018	1.019
1.016	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.015	1.016	1.016	1.017	1.017	1.018	1.018	1.018	1.018	1.019	1.019	1.019	1.019	1.020
1.017	1.016	1.016	1.016	1.016	1.016	1.016	1.016	1.016	1.016	1.017	1.018	1.018	1.019	1.019	1.019	1.019	1.020	1.020	1.020	1.020	1.021
1.018	1.017	1.017	1.017	1.017	1.017	1.017	1.017	1.017	1.017	1.018	1.019	1.019	1.020	1.020	1.020	1.020	1.021	1.021	1.021	1.021	1.022
1.019	1.018	1.018	1.018	1.018	1.018	1.018	1.018	1.018	1.018	1.019	1.020	1.020	1.021	1.021	1.021	1.021	1.022	1.022	1.022	1.022	1.023
1.020	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.020	1.021	1.021	1.022	1.022	1.022	1.022	1.023	1.023	1.023	1.023	1.024
1.021	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.020	1.021	1.022	1.022	1.023	1.023	1.023	1.023	1.024	1.024	1.024	1.025	1.025
1.022	1.021	1.021	1.021	1.021	1.021	1.021	1.021	1.021	1.021	1.022	1.023	1.023	1.024	1.024	1.024	1.024	1.025	1.025	1.025	1.026	1.026
1.023	1.021	1.021	1.022	1.022	1.022	1.022	1.022	1.022	1.022	1.023	1.024	1.024	1.025	1.025	1.025	1.025	1.026	1.026	1.026	1.027	1.027
1.024	1.022	1.022	1.022	1.023	1.023	1.023	1.023	1.023	1.023	1.024	1.025	1.025	1.026	1.026	1.026	1.026	1.027	1.027	1.027	1.028	1.028
1.025	1.023	1.023	1.023	1.023	1.024	1.024	1.024	1.024	1.024	1.025	1.026	1.026	1.027	1.027	1.027	1.027	1.028	1.028	1.028	1.029	1.029
1.026	1.024	1.024	1.024	1.024	1.024	1.025	1.025	1.025	1.025	1.026	1.027	1.027	1.028	1.028	1.028	1.028	1.029	1.029	1.029	1.030	1.030
1.027	1.025	1.025	1.025	1.025	1.025	1.026	1.026	1.026	1.026	1.027	1.028	1.028	1.029	1.029	1.029	1.029	1.030	1.030	1.030	1.031	1.031
1.028	1.026	1.026	1.026	1.026	1.026	1.027	1.027	1.027	1.027	1.028	1.029	1.029	1.030	1.030	1.030	1.031	1.031	1.031	1.031	1.032	1.032
1.029	1.027	1.027	1.027	1.027	1.027	1.027	1.028	1.028	1.028	1.029	1.030	1.030	1.031	1.031	1.031	1.032	1.032	1.032	1.032	1.033	1.033
1.030	1.028	1.028	1.028	1.028	1.028	1.028	1.029	1.029	1.029	1.030	1.031	1.031	1.032	1.032	1.032	1.033	1.033	1.033	1.033	1.034	1.034
1.031	1.029	1.029	1.029	1.029	1.029	1.029	1.030	1.030	1.030	1.031	1.032	1.032	1.033	1.033	1.033	1.034	1.034	1.034	1.034	1.035	1.035

DENSITY - SALINITY CONVERSION TABLE
15°C (59°F)

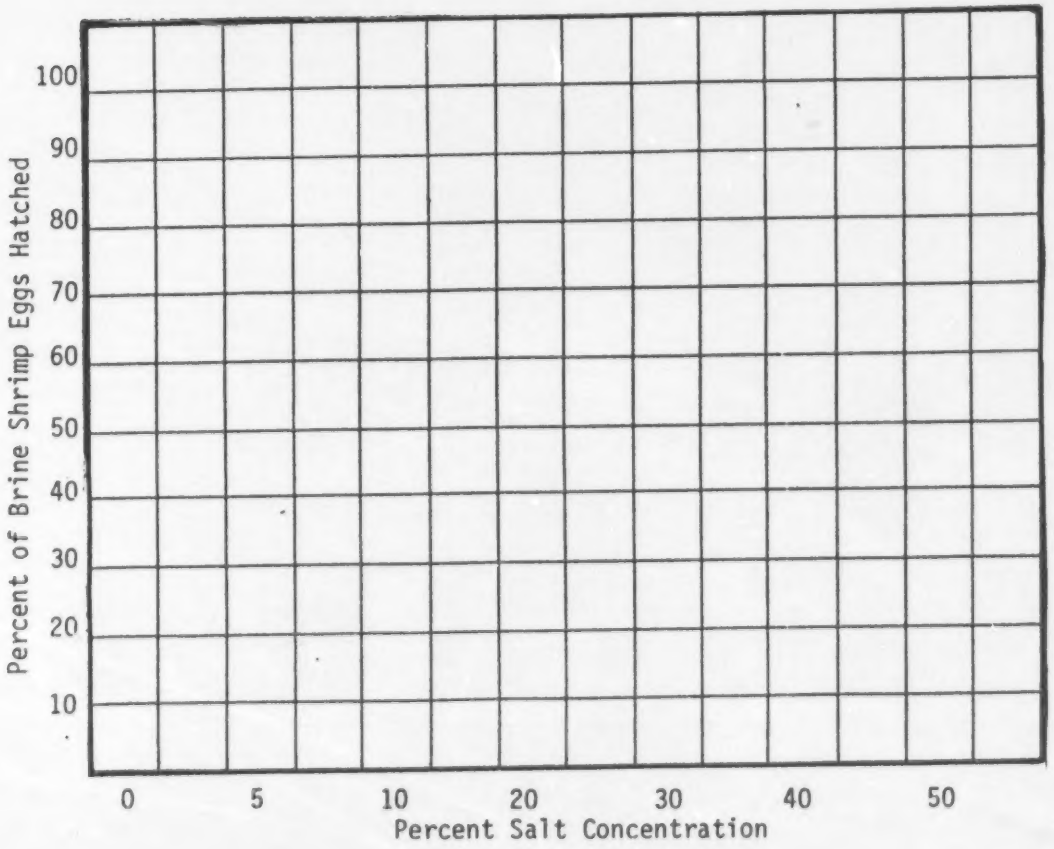
Density (at 15°C)	*Salinity (o/oo)*	*Density (at 15°C)*	*Salinity (o/oo)*
.999	0	1.016	22
1.000	1	1.017	23
1.001	2	1.018	25
1.002	4	1.019	26
1.003	5	1.020	27
1.004	6	1.021	29
1.005	8	1.022	30
1.006	9	1.023	31
1.007	10	1.024	32
1.008	12	1.025	34
1.009	13	1.026	35
1.010	14	1.027	36
1.011	15	1.028	38
1.012	17	1.029	39
1.013	18	1.030	40
1.014	19	1.031	42
1.015	21	1.032	43

HATCHING DATA SHEET

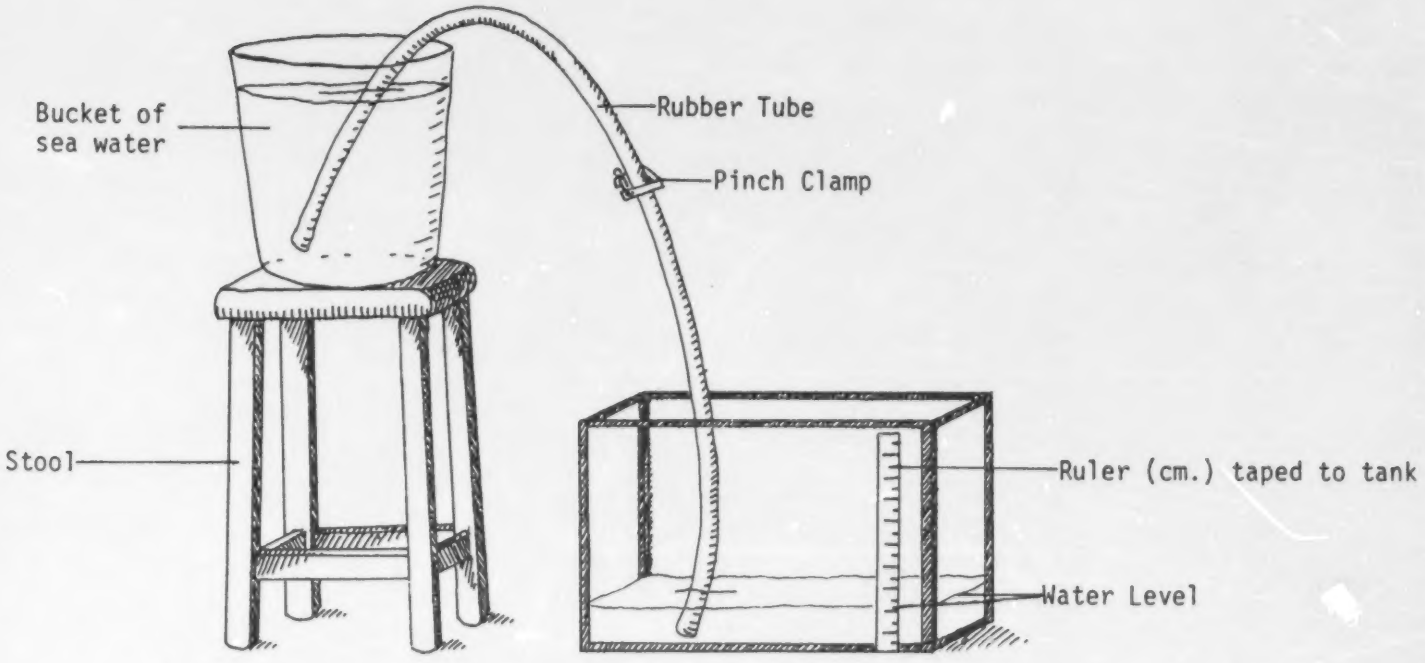
The Effect of Salinity on Brine Shrimp Hatching

Salt Concentration	0%	5%	10%	20%	30%	40%	50%
Number of Eggs Hatched							
Percent Hatching							

HISTOGRAM: The Effect of Salinity on Brine Shrimp Hatching



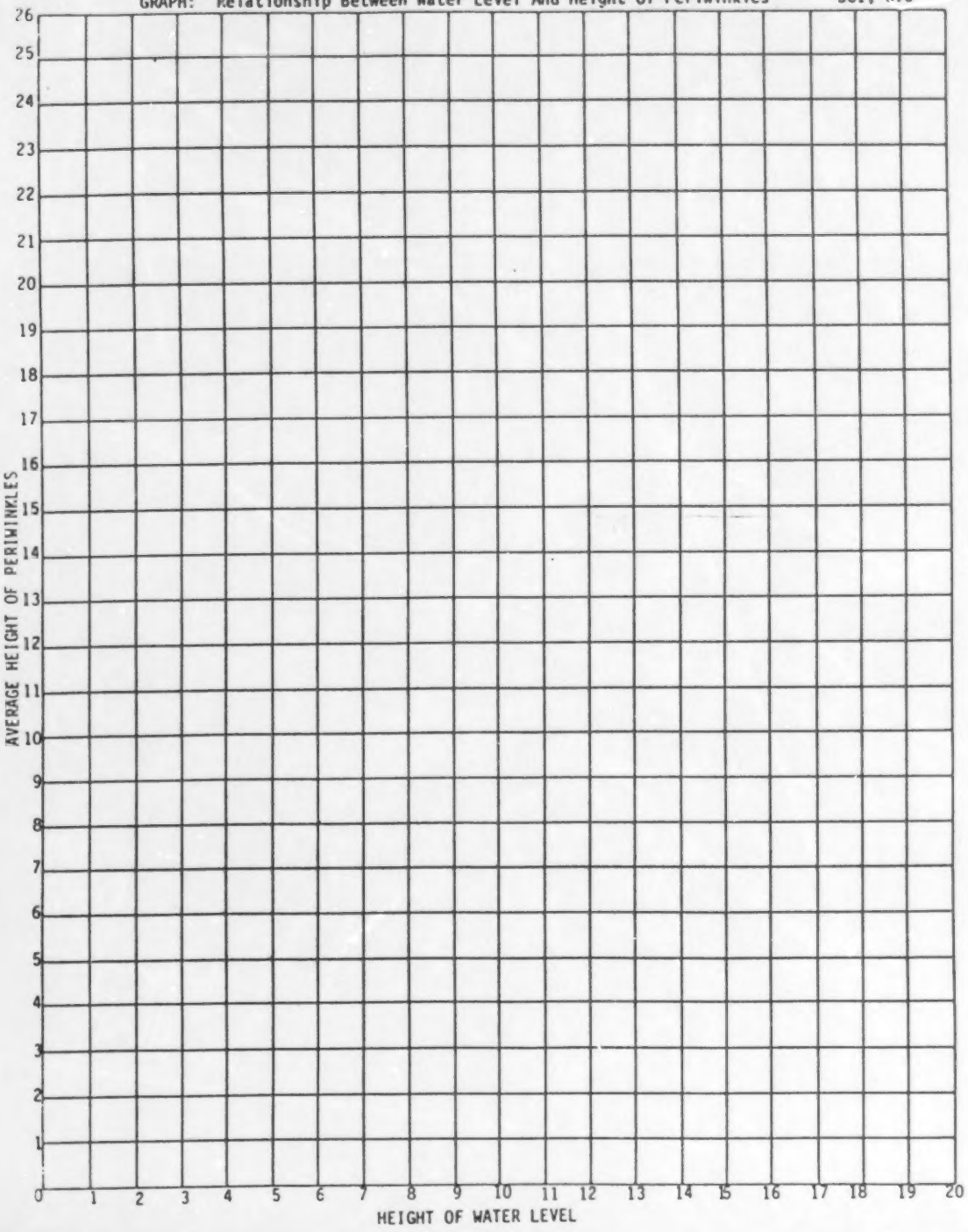
SET-UP FOR MARSH PERIWINKLE BEHAVIOR STUDY



MARSH PERIWINKLE DATA SHEET

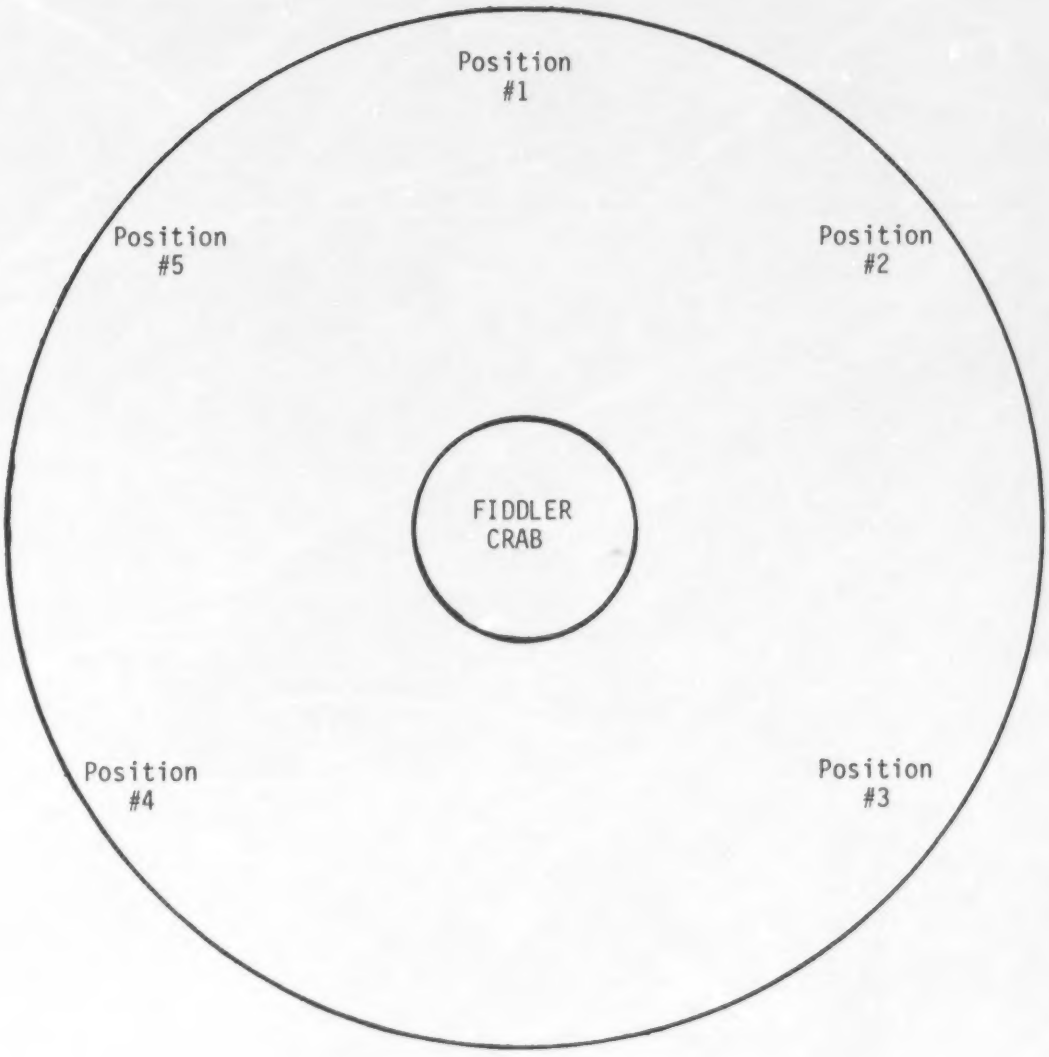
		Water Level Height (cm.)			
Height of Snails	*Snail Number*	5	10	15	20
	1				
	2				
	3				
	4				
	TOTAL				
	AVERAGE				

GRAPH: Relationship Between Water Level And Height Of Periwinkles SCI, 3.3



FIDDLER CRAB

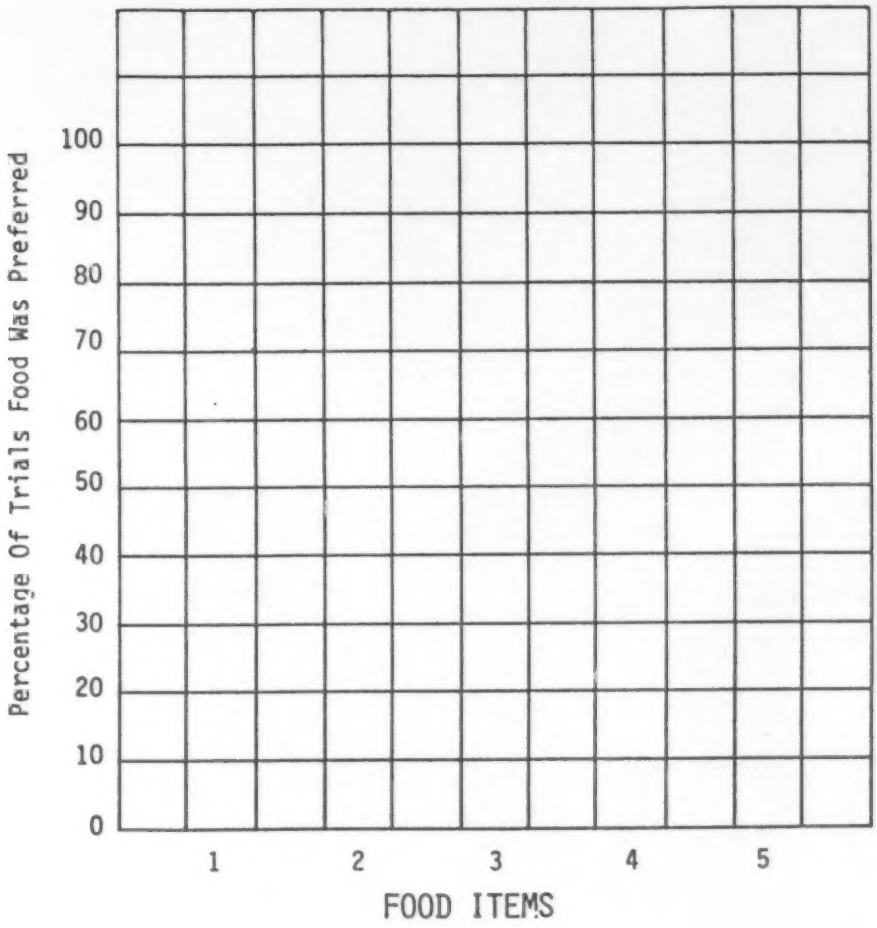
FOOD PREFERENCE CIRCLE



FOOD PREFERENCE DATA SHEET

Position Number	*Type Of Food*	*Tally Of Times Food Was Preferred*	*Number Of Times Food Was Preferred*	*Percentages of Trials Food Preference Occurred*
1				
2				
3				
4				
5				
		Total Number Of Trials		100%

GRAPH: Food Preferences In Fiddler Crabs



FIDDLER CRAB MAZE

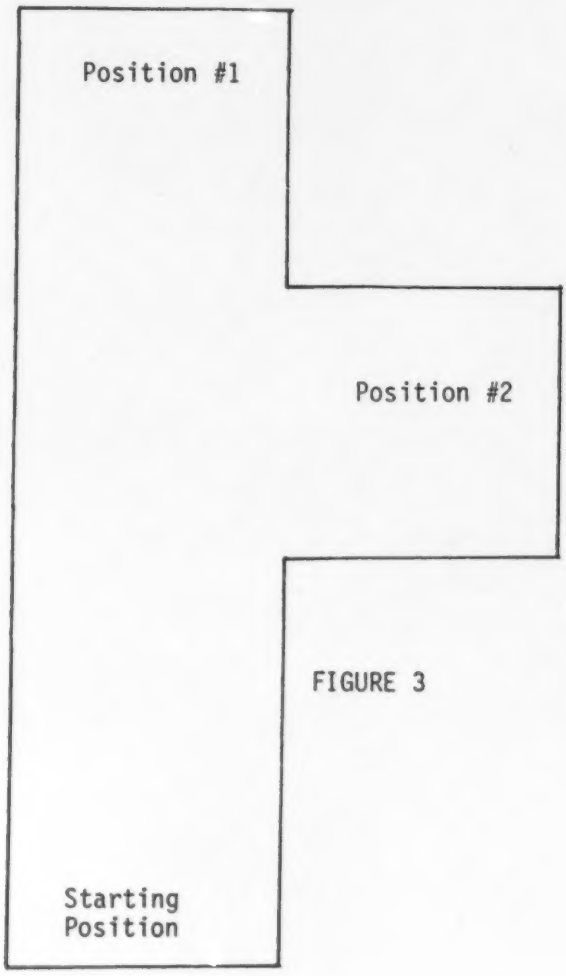


FIGURE 3

FIGURE 1

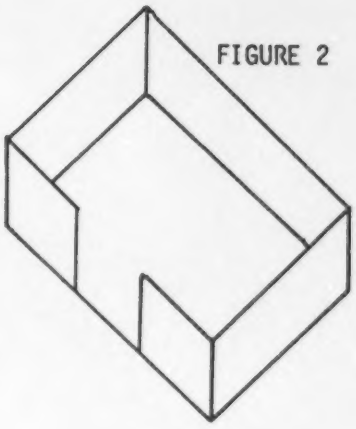


FIGURE 2

Constructing A Fiddler Crab Maze

1. Obtain two cardboard shoe boxes and cut one in half. See Figure 1.

2. Cut the side out of the second shoe box, Figure 2, and tape the shoe box half to it, Figure 3.

CRAB MAZE DATA SHEET

Team Number	*Position #1*			*Position #2*		
	Distance (D)	Time (t)	Rate = D/t	Distance (D)	Time (t)	Rate = D/t
1						
2						
3						
4						
5						
6						
7						
8						
TOTAL						

SC1
6.1

MOLE CRAB DIG DATA SHEET

Crab Number	*Light*		*Moisture*				*Substrate Texture*			
	Bright Light	Subdued Light	Dry Sand	Slightly Moist Sand	Moist Sand	Wet Sand	Fine Mud	Fine Sand	Medium Sand	Coarse Sand
1										
2										
3										
4										
5										
TOTAL										
AVERAGE										